Ultraviolet Curable Powder Coatings With Robotic Curing for Aerospace Applications

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Outline

- Project Team
- UV-Cure Technology
- UV-Curable Powder Overview
- Current Status of ESTCP Project WP-0801

Project Team

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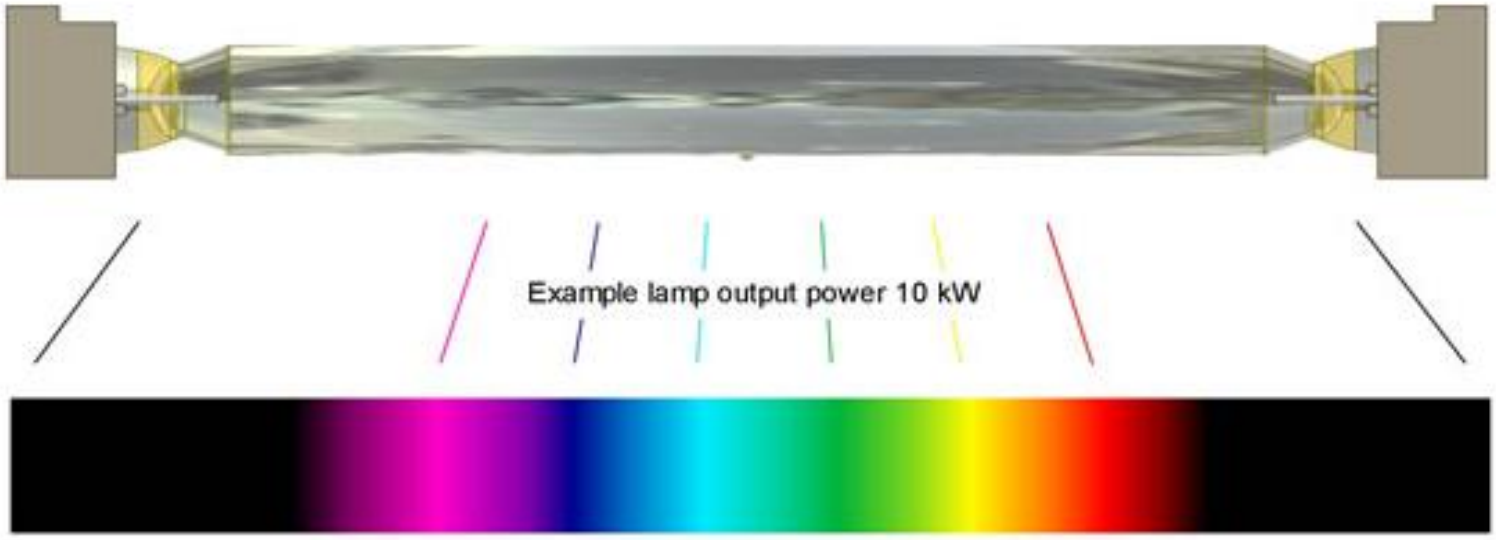
UV Cure Technology

UV Cure Technology

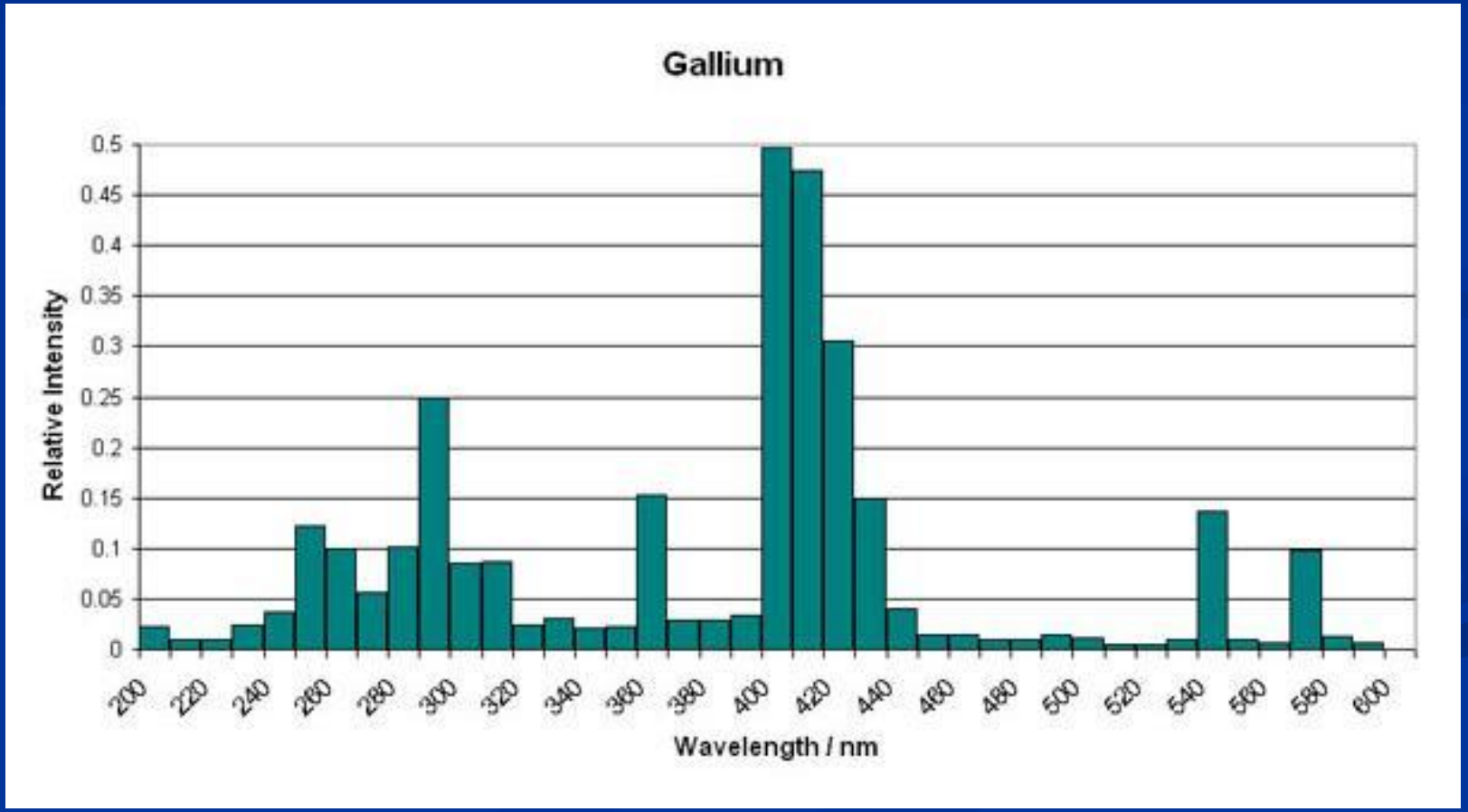


Ultra-violet (100 - 400 nm)	Visible light (400 - 700 nm)	Infra-red (700 - 1000 nm)
Ultra-violet radiation:	Visible light radiation:	Infra-red radiation:
25 - 30%	5 - 10%	60 - 65%
2.5 - 3.0 kW	0.5 - 1.0 kW	6 - 6.5 kW

Typical medium pressure mercury discharge lamp power distribution.

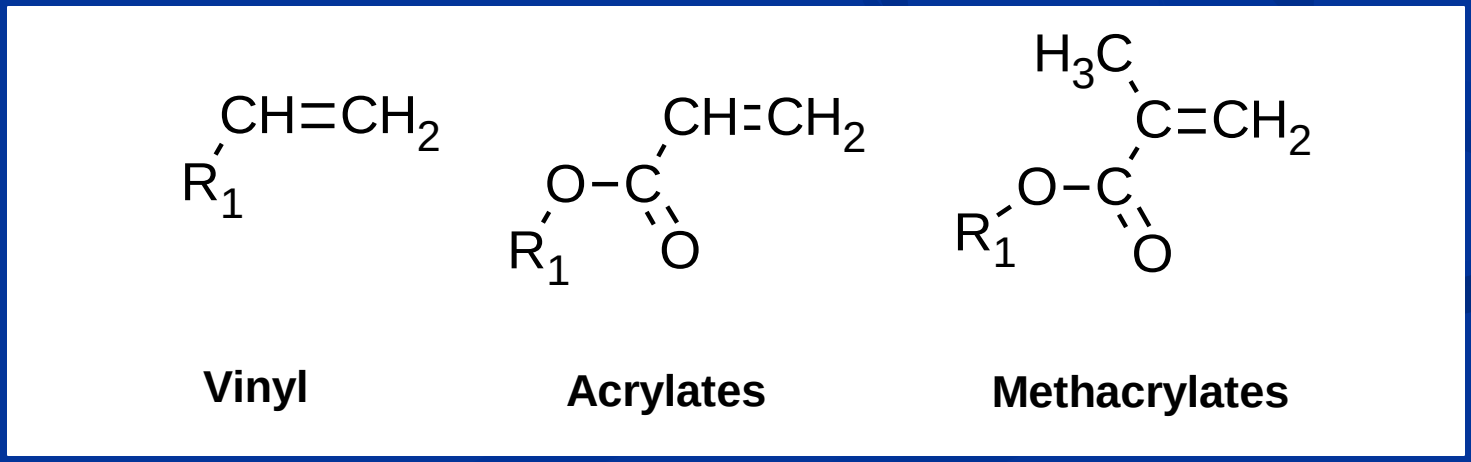
UV-Cure Technology

- Typical Ultraviolet Lamp Spectra:



UV Cure Technology

- Chemistry of UV-cure coatings
  - Can be virtually any polymer matrix used for organic coatings
  - The common denominator is the presence of a UV light reactive species on/in the polymer matrix
  - Commonly vinyl, acrylate or methacrylate groups

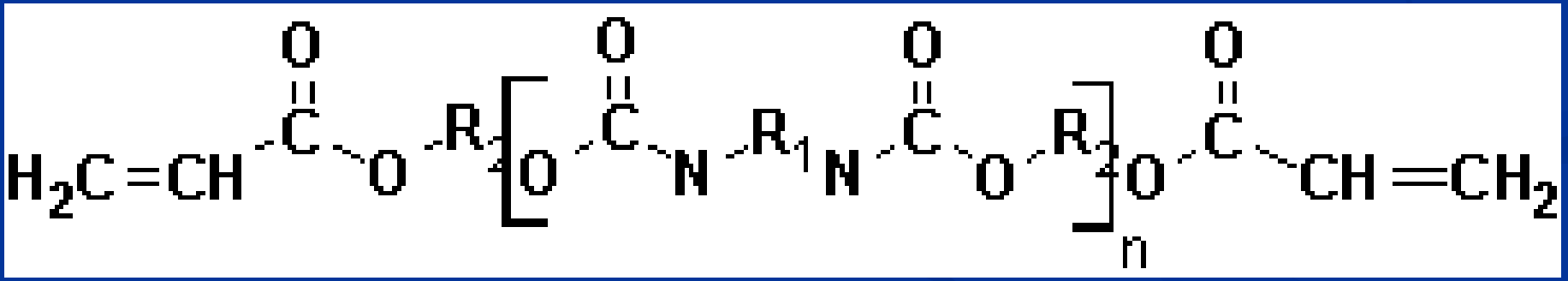


UV Cure Technology

- Chemistry of UV-cure coatings
  - Typically, the most common UV curable powders are:
    - Polyurethanes
    - Polyesters
    - Epoxies
    - Hybrids and mixtures of the above
  - For the UVCPC project, we use a special composition of light activated polyurethanes and polyesters

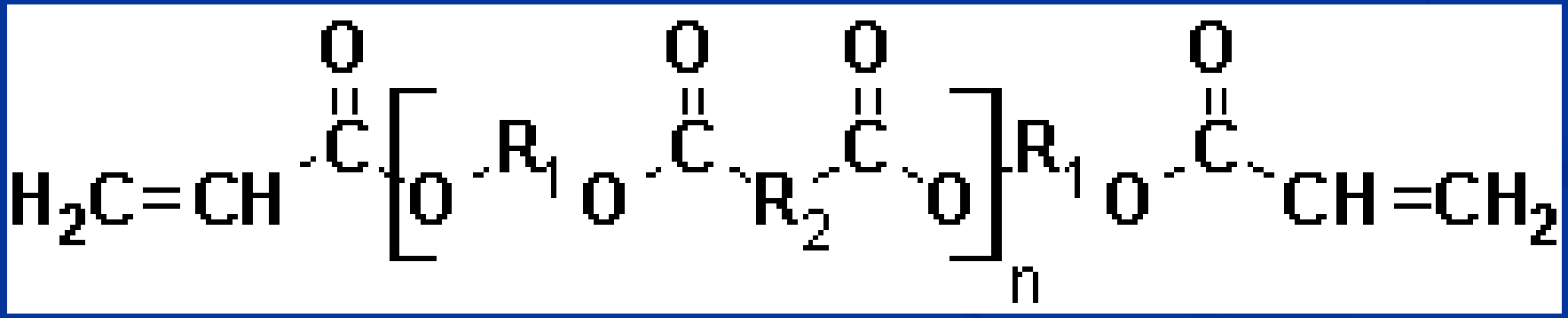
UV Cure Technology

- Polyurethane diacrylate (typical) MW ~2000 - 4000



UV Cure Technology

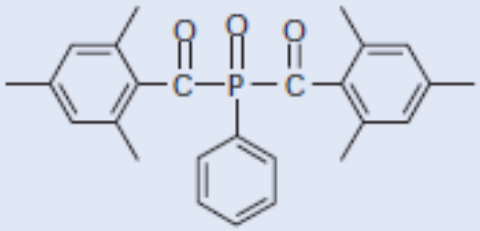
- Polyester diacrylates (typical) MW ~2000 - 4000



UV Cure Technology

- UV Cure formulations require:
  - Light reactive polymer resins
  - Additives such as pigments and flow agents
  - Photoinitiators

IRGACURE 819 and IRGACURE 819 DW



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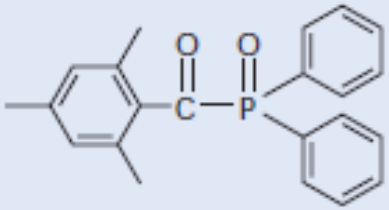


UV-Curable Powder Overview

UV-Curable Powder Overview

- Previous ways of thinking about powder
  - Coating cure temperatures – typically above 220°C
  - Prohibitive for use on tempered metals (Al, Mg, Ti)
  - Prohibitive to use on composites
  - Powder coatings were designed as barrier protection

UV-Curable Powder Overview

- Modern powder coatings can be formulated to have:
  - Lower melt & flow temperatures (< 110°C)
  - UV or EB cure functionality can be added
  - Various advanced non-chrome corrosion inhibitors

UV-Curable Powder Overview

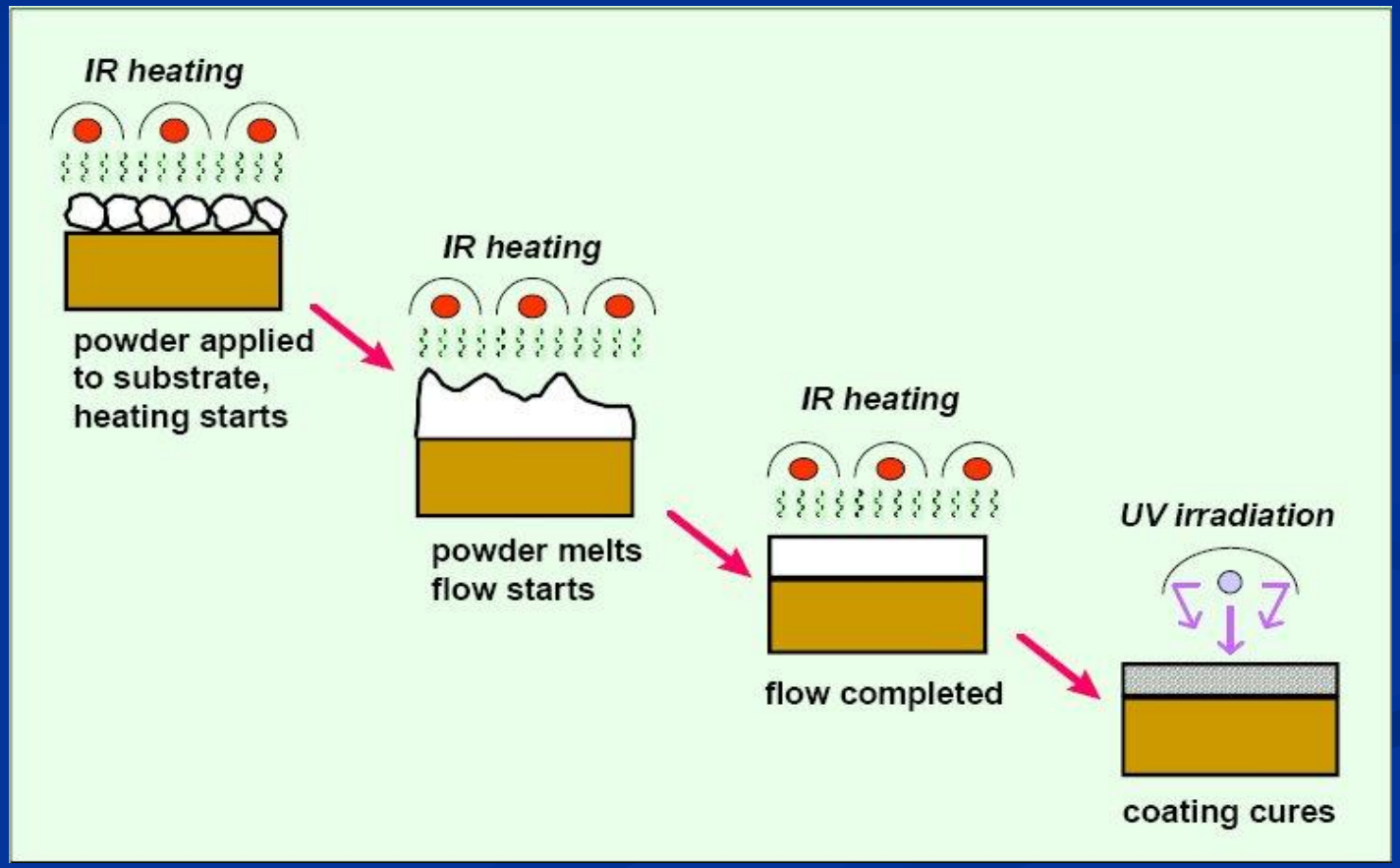
- Advantages of UV-cure powder coating:
  - Elimination of volatile organics (VOC)
  - Elimination of hazardous air pollutants (HAP)
  - Reduction/elimination of hazardous waste
  - Transfer efficiencies as high as 95% (w/reclaim)
  - Decrease in thermal exposure.
  - Large bulky parts that cannot fit into existing ovens can be coated and cured.
  - UV-cure powder requires less energy because the energy is focused to a specific part only as long as needed.

UV Curable Powder Overview

- Powder is applied using electrostatic powder gun
- Applied powder is cured with IR and UV lights mounted on robotic curing system

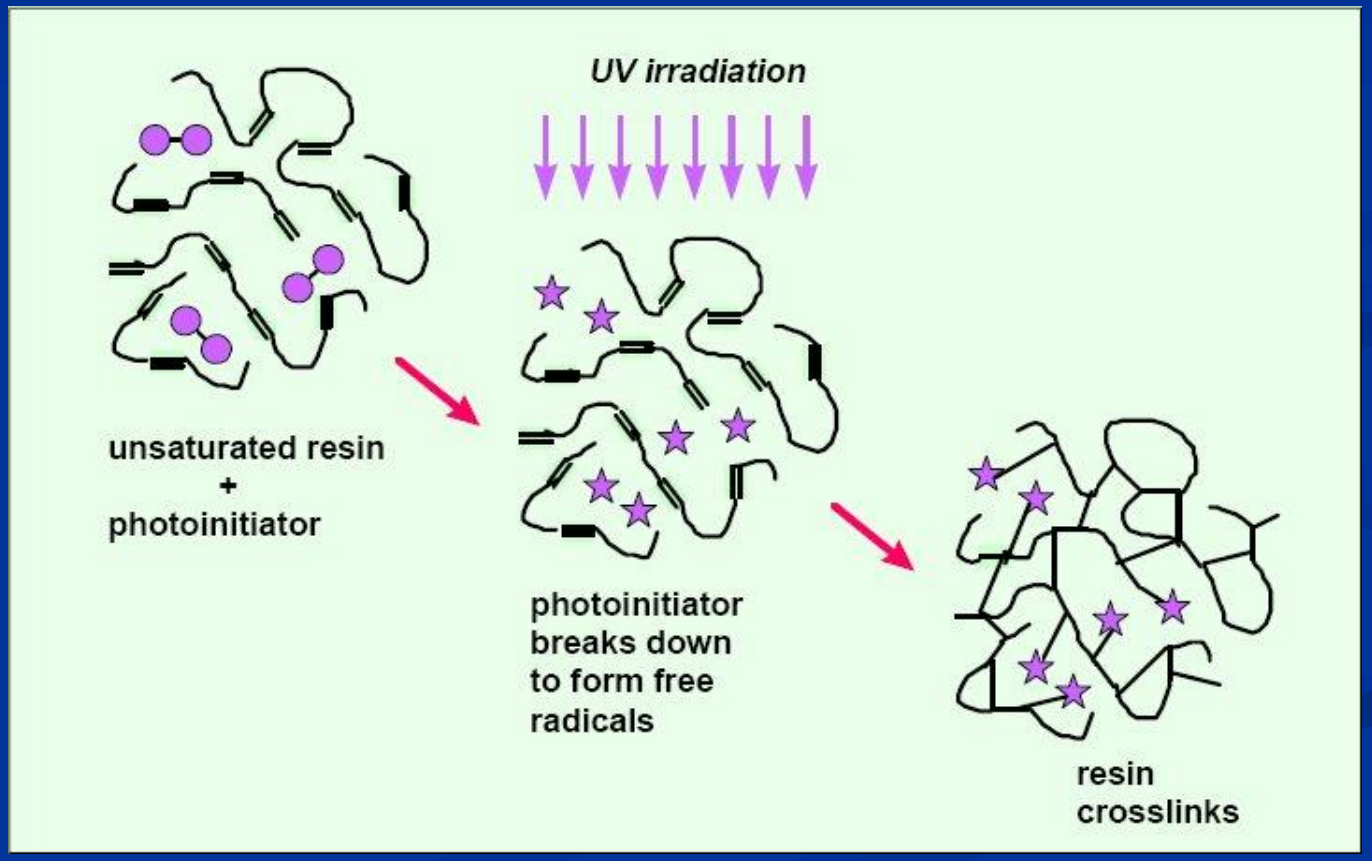
UV Curable Powder Overview

- The UV cure powder process:



UV Curable Powder Overview

- Crosslinking occurs during UV irradiation:



ESTCP Project WP-0801

ESTCP Project WP-0801

- The Problem:
  - DoD spends millions of dollars annually on solvent-based coatings
  - Hexavalent chrome primer use still very widespread
  - Contains or requires volatile solvent use
  - Significant hazardous waste costs
  - Hazardous materials pose risks to human health and environment
  - Process times measured in hours to days
  - Transfer rates are less than 60%

ESTCP Project WP-0801

- The WP-0801 Objectives are:
  - Demonstrate a VOC/HAP-free, Ultraviolet cure powder coating (UVCPC) on DoD hardware
  - Demonstrate state-of-the-art robotics for curing

ESTCP Project WP-0801

- Requirements of a UVCPC for military use:
  - Must perform at least as well as MIL-PRF-23377 primer
  - Must also perform as well as MIL-PRF-85285 topcoat
  - Can be prepared in gloss, semi-gloss, and flat finishes

ESTCP Project WP-0801

- Robotic Curing System:
  - Robot carries the Infrared and Hg vapor UV lamps

ESTCP Project WP-0801

- UV Cure Powder:
  - Currently utilizing one vendor
  - Three colors, two gloss whites, one semi-gloss gray
  - Current powder melts and flows at 115°C
  - Has undergone a number of tests to validate performance
  - The current powder has no Chromium, Molybdenum, Vanadium, Barium, or any rare earth inhibitors
  - In fact, it has no corrosion inhibitors

ESTCP Project WP-0801

- UV Cure Powder Performance Summary:
  - Greater than 4400 hours scribed B117 salt spray
  - 18 months on beach with shiny scribes
  - Better than the control in 1000 hour filiform
  - UVCPC is 38% more durable in falling sand testing
  - Easily passed fluid immersion testing
  - Strippability demonstrated

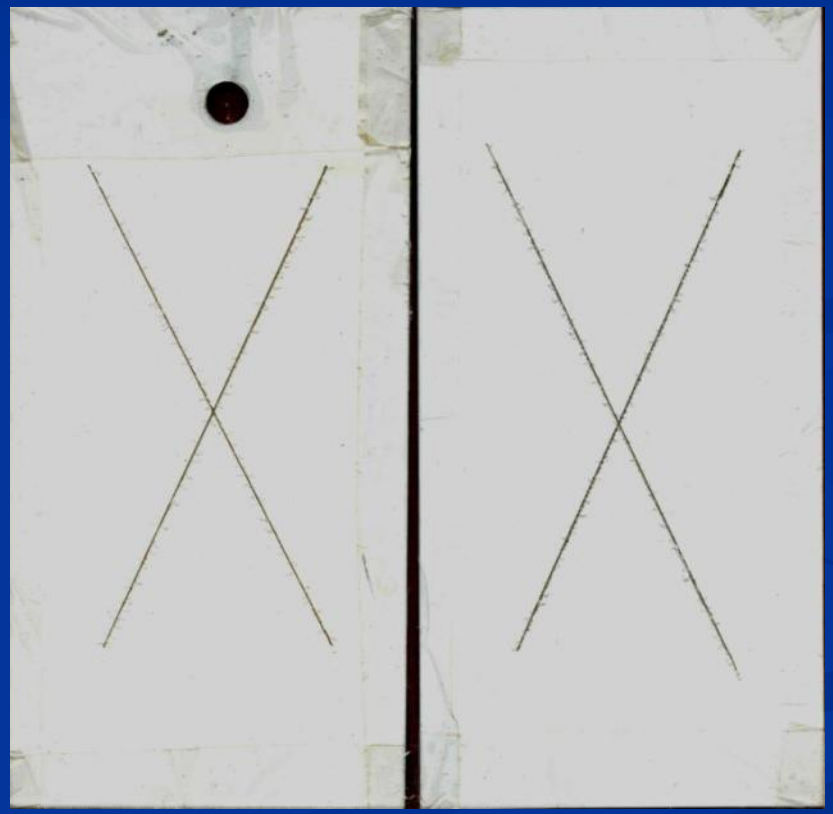
ESTCP Project WP-0801

- Salt Spray Panels
  - 12 months on beach
  - 4400 plus hours B117

12-month beach 4400 hour B117

ESTCP Project WP-0801

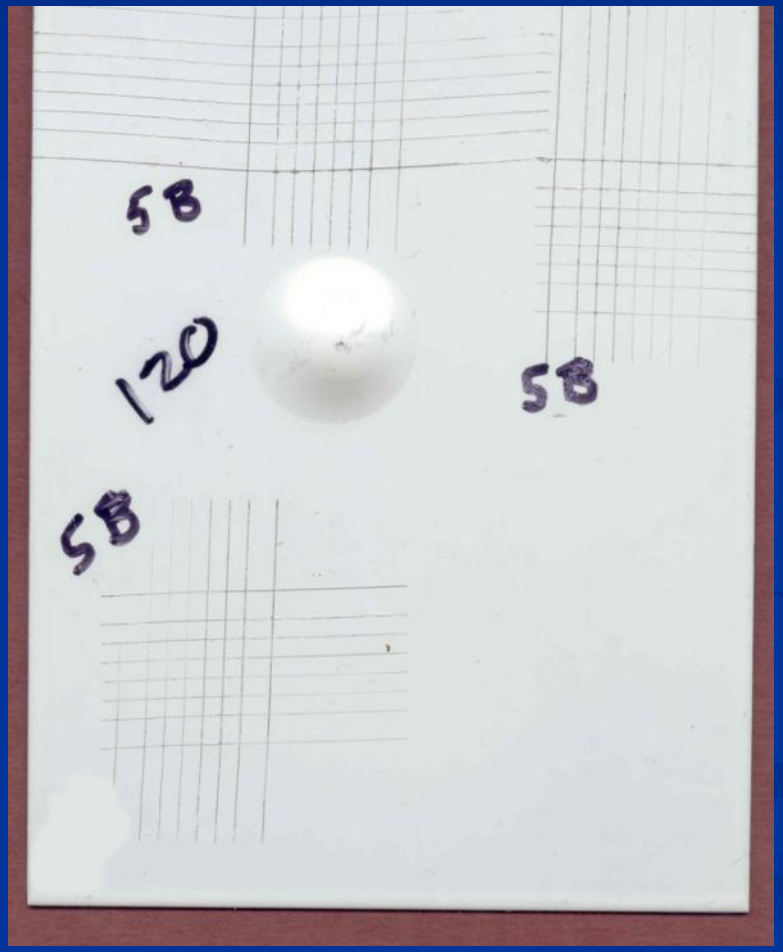
- Filiform corrosion resistance results
  - Testing performed by NAVAIR, Patuxent River
  - Panels removed after 1000 hours without failure



UVCPC Control

ESTCP Project WP-0801

- **Reverse Impact Flexibility**
  - **>120 in-lb**

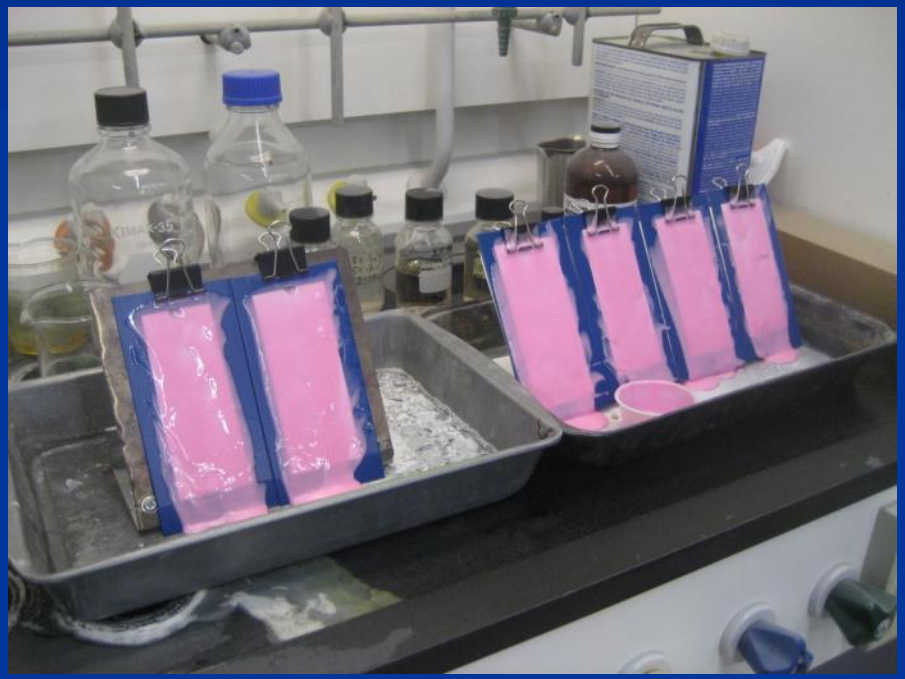


ESTCP Project WP-0801

- **Fluid Immersion Resistance**

ESTCP Project WP-0801

- Strippability Tests

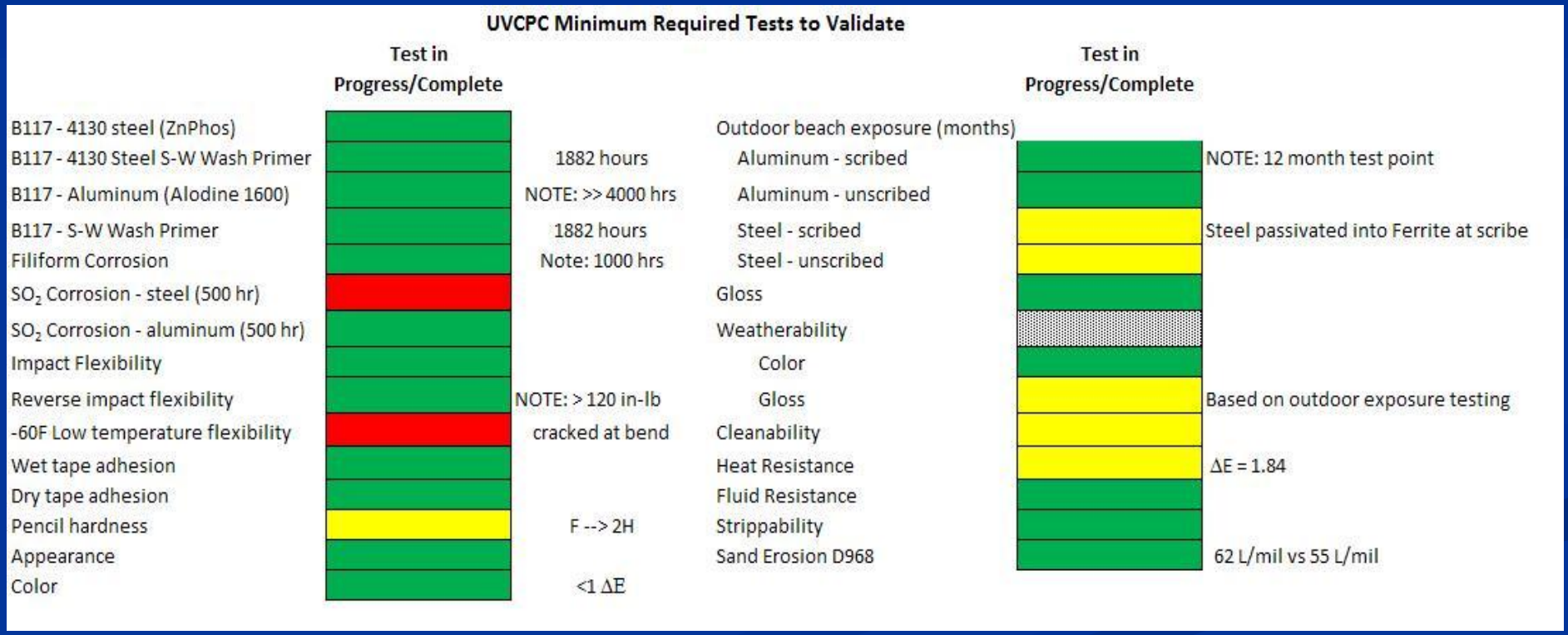


Initial stripper applied

UVCPC after 4 hours

ESTCP Project WP-0801

- **Summary of Validation Testing**



ESTCP Project WP-0801

- Planned demonstration weapon systems:

EA-6B wheels, landing gear

HH-65 helicopter

P-3 wheels, landing gear, radomes

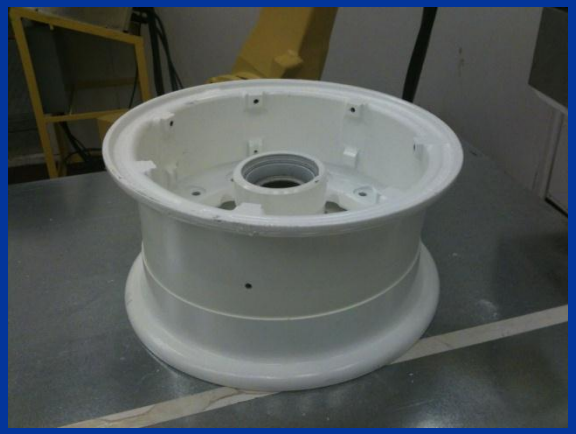
Mk-48 ADCAP torpedo

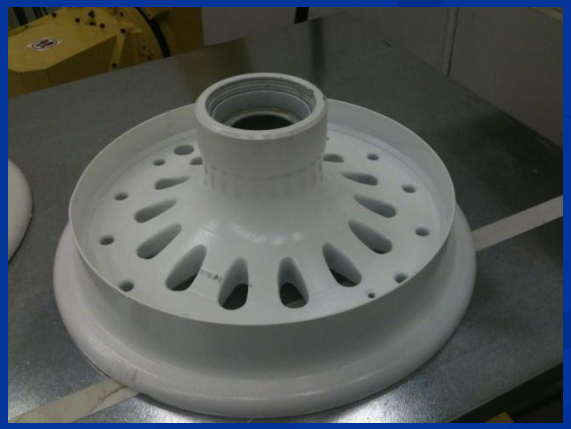
HC-130 main landing gear doors

Ammunition and storage cases

ESTCP Project WP-0801

- Studies:
  - UVCPC aircraft wheels for PEWG
  - Successfully demonstrated capability to electrostatically powder coat otherwise non-conductive materials.





Questions?